MODEL P-2000

LASER BASED MICROPIPETTE PULLER

SUTTER INSTRUMENT COMPANY

40 LEVERONI COURT NOVATO, CA

94949

(415) 883 - 0128

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U N P A K I N G A N D S E T T I N G U P

The Model P-2000 is shipped to you in a prefabricated foam mold. Please take note of this method of packaging. Should it ever be necessary to ship the puller to another location, the same method of packaging should be employed.(Additional packing material may be purchased from Sutter Instruments.)

IMPORTANT: Improper packaging is a form of abuse, and as such can be responsible for voiding the warranty where shipping damage is sustained as a result of such packing.

Place the puller in a location where there is a free flow of fresh air on all sides. The fan draws air in through the vent on the back of the instrument and exhausts it out from the top plate. NEVER ALLOW THE FREE FLOW OF AIR TO BE RESTRICTED.

The P-2000 is a CO2 laser based micropipette puller. A number of safety shields, enclosures and interlocks have been built in to the instrument to protect the user from any radiation exposure. Under no circumstances should the safety enclosures be removed or the interlocks defeated. Up to 20 watts of CO2 laser power could be accessible under the top cover. "Caution - use of controls or adjustments or performance of procedures other than those specified herein may result in hazardous radiation exposure."

First Time Use

Plug the instrument into a power receptacle of the correct voltage and frequency. NOTE: Since the P-2000 is a microprocessor controlled device, it should be accorded the same system wiring precautions as any 'computer type' system. If microprocessor based systems in the lab require line surge protection for proper operation, then the same protection should be provided for the P-2000.

In order to protect the tilting mechanism associated with the scanning mirror, a shipping screw has been installed next to the micrometer located at the back of the instrument. This screw is turned down prior to shipping to unload the micrometer. Before using the puller, run this screw up (turn counter-clockwise) until it is nearly out of the baseplate. There should be a factory default setting indicated near the micrometer. Make sure that the micrometer is set as indicated. If you are not sure how to read a micrometer, consult the maintenance section.

The P-2000 was shipped to you with several sample programs already installed. The chart on the following page lists the program numbers and identifies the purpose of the programs.

P-2000 Factory Installed Programs

PROGRAM	GLASS COMPOSITION	GLASS SIZE (ID X OD)	TYPE OF PIPETTE
0	QUARTZ	1.0 x 0.7 mm	Micropipette
1	QUARTZ	1.0 x 0.5 mm	Patch
10	BOROSILICATE	1.0 x 0.5 mm	Micropipette
11	BOROSILICATE	1.0 x 0.5 mm	Patch
20	ALUMINOSILICATE	1.0 x 0.5 mm	Micropipette
21	ALUMINOSILICATE	1.0 x 0.5 mm	Patch

To change from one program to another, press the reset button on the front panel and then select the program number on the keypad followed by the ENTR key. DO NOT USE OTHER PROGRAMS OR CHANGE THE VALUES IN THESE PROGRAMS UNTIL YOU HAVE READ SECTIONS II, III AND IV OF THIS MANUAL.

Should you plan on using the P-2000 with a glass fiber or tube that has been coated with any combustible material, it is highly recommended that you remove the coating from the glass prior to executing a pull. The smoke that is generated from the various combustible coatings is likely to coat the retroreflective mirror and interfere with proper performance of the P-2000.

To execute a program, clamp a piece of glass tube in the puller bars (glass loading is described in the operation section of this manual), lower the plastic top and then press the PULL key on the keypad. If the glass does not separate within 15 seconds, press the STOP key to turn the laser off. Please read this manual in its entirety before proceeding with program or optical adjustments.

MECHANICAL DESCRIPTION

CONTROLS & ADJUSTMENTS

This section presents a basic mechanical description of the P-2000, with particular emphasis on terminology. Knowing the names of the various parts greatly facilitates communication between the investigators and the manufacturer when discussing adjustments or service problems. In addition, various controls and adjustments on the top of the instrument are located and described. Those adjustments which are considered part of maintenance procedures are dealt with in Section V.

BASEPLATE (Fig. 1): The baseplate is the metal plate on which is mounted the laser, puller panels, cover plate, etc.

PLASTIC COVER (Fig. 1): This cover encloses the mechanical assembly and prevents access to any stray laser radiation during operation. Two safety interlock switches prevent activation of the laser if the plastic cover is open.

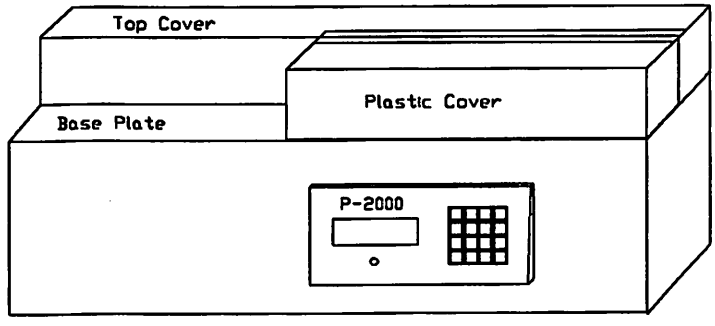


Figure 1: Front View of P-2000

BASE (Fig. 1): The base contains the laser power supply, transformers, circuit board and pull solenoid assembly.

TOP COVER (Fig. 1): This cover safely encloses the laser, the stepper motor and scanning mirror assembly. Warning: To avoid possible exposure to invisible laser radiation, under no circumstances should this enclosure be removed.

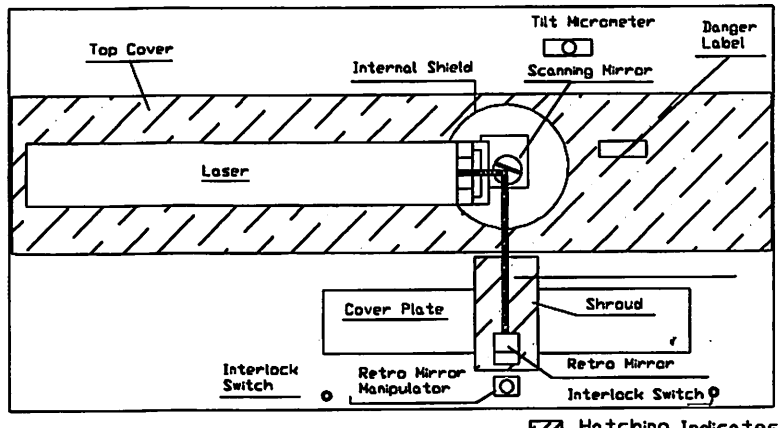


Figure 2: Top View of P-2000

COVER PLATES (Fig. 2): The cover plate conceals the entry of

the pulling cables into the base of the instrument.

PANELS, LEFT AND RIGHT (Fig. 3k): The panels are the angled surfaces upon which are mounted the puller bars and their bearings, the spring stops, the bumpers, and the upper cable pulley assemblies. Except for minor differences in shape, the left and right panels are identical. Note the three socket-head cap screws that attach each panel to the top. These screws are used to align the pullers bars. Puller bar alignment is covered in the maintenance section.

PULLER BARS (Fig. 3r): This assembly consists of the puller bar, glass clamp, clamping knob and cable retaining screw. The puller bar is made of mild steel and coated with a controlled thickness of hard chrome. Glass is loaded into the V groove near the tip of the puller bar and is held in position by tightening down the clamp knob. Pullers modified for pulling optical fibers have a shallow slit in the bars rather than a groove. The cable retaining screw holds the cable in a shallow groove at the end of the puller bar, and forms the 'resistance' against which the cable ends pull.

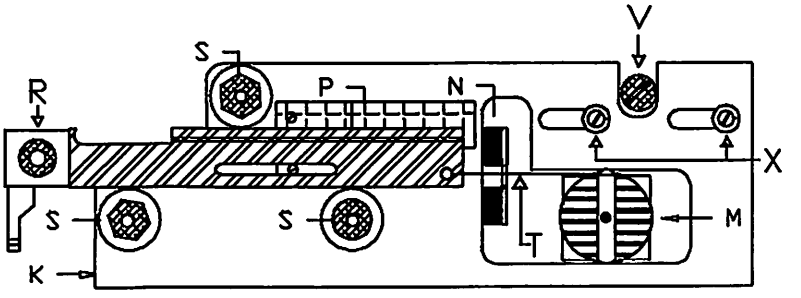


Figure 3: Components Mounted On Puller Panel (Right Panel Shown)

V-BEARINGS (Fig. 3s): These bearings are the guides for puller bar motion. They are made of stainless steel and should NEVER be oiled (see maintenance section). Note that these bearings are mounted on stainless steel bushings one of which is round, and the other two being hexagonal. The hexagonal bushings are used to adjust position and ease of travel of the puller bars (see maintenance section).

BUMPERS (Fig. 3n): The bumper stops the motion of its associated puller bar and prevents impact forces from breaking the tips.

SPRINGS STOPS (Fig. 3p): The spring stops are one way catches that prevent pipette tip collision by catching the puller bars as they rebound off the bumbers.

UPPER CABLE PULLEY ASSEMBLY (Fig. 3m): This assembly conducts the pulling cables from the puller bars to the centrally located (and concealed) lower pulley assembly. Note that this assembly is attached to its panel by two screws, in slots, and contains a large eccentric ad-

justment screw. This eccentric screw is used to adjust cable 'tension'. Its use is covered in the maintenance section.

PULL CABLE (Fig.3t): This cable conducts the pulling force of the solenoid to the puller bars via the upper and lower pulley assemblies. It is made of flexible metal with a nylon coating. NEVER PINCH OR DISTORT THE CABLE. The cable is terminated with crimped-on clamps or 'swages'.

SHROUD (Fig. 2): This enclosure houses the retroreflective mirror and prevents user access to the laser beam. All glass heating occurs within this enclosure. The shroud is attached to the cover plate with two slot head screws. The shroud can be removed to allow access to the retro-reflective mirror (see maintenance section).

MANIPULATOR (Fig.2): The two stage manipulator is used to adjust the position of the retroreflective mirror.

Optical Components:

LASER (Fig. 2): A 10 watt C02 laser provides the heat source for melting the glass. Laser output power is regulated by feedback control electronics. The laser output power is specified by the program value entered for HEAT.

SCANNING MIRROR (Fig.2): The laser beam is projected onto the back face of the glass by a reflective mirror. This mirror is mounted on a rotating base driven by a stepper motor. Heat application to the glass is achieved by repeatedly scanning the mirror between the limits of a defined longitudinal area.

SCANNING MIRROR TILT MIROMETER (Fig.2): The scanning mirror is mounted on a tilting table. The tilt controls the elevation of the laser beam relative to the glass. The degree of tilt is controlled by the micrometer located at the back of the puller. In order to protect the tilting mechanism, a shipping screw has been installed next to the micrometer. This screw is turned down prior to shipping to unload the micrometer and lock the table in place. Before using the puller, run this screw up (turn counter-clockwise) until it is nearly out of the baseplate. There should be a factory default setting indicated near the micrometer. Make sure that the micrometer is set as indicated. If you are not sure how to read a micrometer, consult the text in the maintenance section.

RETROREFLECTIVE MIRROR (Fig. 2): The portion of the beam that is projected past the tubing is collected by a reflective concave mirror mounted behing the tubing. This retroreflective mirror redirects the divergent laser radiation onto the front side of the glass and thereby provides relatively uniform heating around the circumference of the glass.

Optical Alignment:

Proper alignment of both the front scanning mirror and rear collector mirror is critical for optimizing the performance of the laser puller. Both mirrors have been adjusted for optimum performance using 1mm outside diameter glass (unless otherwise noted). If you will be using larger diameter glass, please read the comments on glass size in Section IV. We recommend that you refrain from adjusting the mirrors until you have spoken with a member of the Sutter Instrument technical staff. In the event that you do need to adjust the mirrors, consult the maintenance section for instructions

FRONT PANEL DESCRIPTION AND OPERATION

The aim of this section is to provide the user with the information necessary to operate the P-2000. It begins with some important definitions and descriptions of the front panel controls.

PROGRAM: A program consists of one or more cycles, which when executed in sequence will 'pull' the capillary glass inserted in the instrument. A program can be up to 16 cycles in length.

CYCLE: A cycle consists of a HEAT value, a FIL(Filament) number, a VEL.(Velocity) value, a DEL(Delay) value and a PULL value.

The sequence of events during execution of a cycle is as follows:

- 1) The Laser turns on
- 2) The glass heats up and a weak pull draws the glass apart until it reaches the criteria Velocity
- 3) The hard Pull (if any) is executed relative to the programmed Delay.

LOOP: A loop consists of one or more cycles that are repeated by the instrument until glass separation is achieved.

RAMP TEST: A ROM resident program designed to facilitate program alterations when selecting different filaments and/or when using different glass tubing. The test is described in subsequent text.

Front Panel Controls

RESET: When momentarily pushed, this switch resets the microprocessor to an initialized condition. It is used to change from one program to another, and in other circumstances as described below.

KEYPAD: There are three 'groupings' of keys on the keypad: numerical/decision, editing and control. They function as follows:

NUMERICAL/DECISION (0-9): These keys are used to enter the number of the program being chosen, the various values for HEAT, PULL etc. and to make yes/no (1/0) decisions in certain situations.

EDITING (CLR, ENTR, NEXT, LAST): These keys are used for entering, deleting and editing programs. They allow one to move forward and back through a program, enter new values, and clear out unwanted values. In addition, the CLR key is the access key to the Ramp Test. The function of the various keys will be explained in the context of instrument operation in subsequent text.

CONTROL (PULL, STOP): These keys control the initiation and cessation of program execution and control of the Ramp Test.

Display Parameters

HEAT (Range - ramp minimum to 999): Specifies the output power of the laser, and consequently the amount of energy supplied to the glass. Generally, changes will be made in steps of about 10 units since in most cases smaller changes will have no effect.

FILAMENT (Range- 0 to 15): Heat is supplied to the glass by longitudinally scanning the laser beam onto the glass in a length and rate dependent manner. The P-2000 is preprogrammed with 16 different scanning patterns, each of which constitutes a different filament. Filaments vary both in the length of glass heated and the scan rate within this length. The length of the area scanned is analagous to the width of a conventional metal heating filament. The scan rate relates to the laser power (heat) distribution. The following charts lists the relationship between a selected filament number and the length and rate of the beam scan.

Filament #	0	1,6,11	2, 7, 12	3, 8, 13	4, 9, 14	5, 10, 15
Scan Length	1.0 mm	1.5 mm	1.9 mm	4.5 mm	6.5 mm	8.0 mm

Filament #	0	1 - 5	6 - 10	11 - 15

Scan Rate	No Scan	High	Medium	Slow

VELOCITY (Range- 1 to 255): The velocity of the system is measured as the glass softens and begins to pull apart under a constant load. The increasing velocity of the initial pull is determined by the viscosity of the glass, which in turn is a function of the glass temperature. The adjustable velocity allows for selection of a precise glass temperature as the trip point for the hard pull. One unit represents a change of one or more millivolts of transducer output depending on the transducer being used. Useful values for velocity range from 10 to 100 with the lower values being used for fibers and higher values for micropipettes.

DELAY (Range- 1 to 255): The DEL variable controls the timing of the start of the hard pull relative to the deactivation of the laser. An increase in the value of DEL will cause the glass to be cooler when the hard pull occurs. Shorter pipettes may thus be obtained by increasing DEL.

The actual significance of the DEL is slightly more involved than a simple delay. For a DEL value of 128, the hard pull will turn on just as the heat turns off. Each additional unit of DEL will produce a 1 msec delay of the hard pull. Thus at the maximum value of 255, the hard pull will be delayed by 127 msec. Values below 128 advance the onset of the hard pull relative to the end of heat so that the hard pull will start prior to the end of heating. For each unit that DEL is decreased below 128, the heat will remain on for about 1 msec after the start of the hard pull. For the minimum value of DEL 1, the heat will therefore remain on for 127 msec after the hard pull has turned on.

PULL (Range-0 to 255): A change of one unit represents a change of 4 milliamps of current through the pull solenoid. In the case of pull strength useful changes are 10 units or more to see an effect.

O P E R A T I O N

Apply power to the instrument. After an automatic 'power on' reset, the display will appear as follows:

```
WHAT PROGRAM DO YOU WISH TO USE? (0-64)
COPYRIGHT SUTTER INSTRUMENT CORP. 1992
```

The P-2000 is shipped with the following programs already stored in memory:

PROGRAM	GLASS COMPOSITION	GLASS SIZE (ID X OD)	TYPE OF PIPETTE
0	QUARTZ	1.0 x 0.7 mm	Micropipette
1	QUARTZ	1.0 x 0.5 mm	Patch
10	BOROSILICATE	1.0 x 0.5 mm	Micropipette
11	BOROSILICATE	1.0 x 0.5 mm	Patch
20	ALUMINOSILICATE	1.0 x 0.5 mm	Micropipette
21	ALUMINOSILICATE	1.0 x 0.5 mm	Patch

To select a program, enter the program number followed by the ENTR key. Load an appropriate piece of glass into position. This is best done by loosening the glass clamp on the right or left puller bar and sliding the capillary through the clamp until it projects about 1 centimeter beyond the clamp. Release both puller bars and pull them to the center until they stop. Now slide the glass through the hole in the shroud and into the glass clamp on the opposite puller bar and tighten the two knobs on the glass clamps. The knobs can be tightened quite a bit without breaking the glass, but a tremendous amount of force is unnecessary. Lower the plastic cover. Press the PULL key and the puller will execute the program. During program execution(i.e. when ever the laser is active), you will hear the fan in the cabinet base turn off. This is normal operating procedure and does not indicate instrument malfunction.

In order to insure proper operation of the safety interlocks, the status of the interlocks is monitored by the microprocessor. If the plastic cover is not closed when Pull is pressed, the program will not execute and the message " the cover is open. please close the cover and press pull again" will be displayed until the cover is closed. At the end of pull the message "pull completed ....." will be displayed until the cover has been opened. If this message does not remain until the cover is opened, there may be a problem with the interlock.

Remove the pulled pipettes from the glass clamps and press the RESET button. Once again the display shows the message:

WHAT PROGRAM DO YOU WANT TO USE (0-64)
COPYRIGHT SUTTER INSTRUMENT CORP. 1992

At this point there are three options:

- 1) Choose an existing program, load glass and execute the pull;
- 2) Run the Ramp Test;
- 3) Create a new program or edit an old one. The user should now run a Ramp Test.

Ramp Test

The Ramp Test is a self-test function for:

- 1) Establishing an appropriate Heat value for use with your glass;
- 2) Establishing the minimum Heat value which results with instability of the laser output power.

To access the Ramp Test you must first be entered into a program. Press the CLR key. The following message is displayed:

DO YOU WISH TO CLEAR ALL VALUES FROM THE PRESENT CYCLE TO THE END? NO=0 YES=1

A 'no' or '0' response to the above question provides access to the Ramp Test and the following display:

DO YOU WISH TO PERFORM A TEST FUNCTION?
NO=0 RAMP = 1 MEMORY TEST= 2

A '0' response returns the user to the current program. A '1' response results with the following message:

INSERT THE GLASS. CLAMP AND PRESS PULL

Load a length of capillary glass into the puller, lower the plastic cover and the press the PULL key. Upon pressing Pull, the following message is displayed:

WHICH FILAMENT DO YOU WISH TO USE?
0 - 15 THEN PRESS ENTER

Enter a filament number between 0 and 15 followed by the ENTR key.

The Ramp Test will begin to execute with the following events taking place:

- 1) The laser is turned on at full power for 250 msec. after which the command voltage is decreased until the power output from the laser reaches a minimum criteria;
- 2) The laser command voltage is set to correspond to a Heat value of 150;
- 3) The mirror is rotated to focus the beam on the glass, and laser command voltage is incremented. The glass will begin to soften, causing the puller bars move apart with increasing velocity;
- 4) When a criteria velocity is achieved, the laser is turned off and the laser heat value (Ramp Test value) and minimum heat value are reported.

Press RESET to exit from the Ramp Test display, and return to the program select display.

Ramp test operation requires that a considerable amount of power be dissipated by a field effect transitor gating the laser. You are advised to avoid running consecutive Ramp tests which might tax the thermal resistance of the FET.

Entering A New Program /Editing A Program

From the program select display, enter a program number other than the factory installed programs 0,1,10,11,20 or 21. The display should come up with no values for HEAT, PULL, etc. If there are already program values entered, make sure that the program was not entered by another user of the puller. Unused program areas are usually cleared out before a puller is shipped, but occasionally random values or test program values are inadvertently left in memory.

Entering and editing programs requires use of the ENTR, CLR NEXT, and LAST keys. These keys will now be explained.

CLEAR: When a new program is being entered into memory in an area occupied by another program it is helpful to be able to 'clean out' the old program. Also, it may be desirable to remove all the values from the last cycles of a long multi-cycle program to allow for fine tuning of these final cycles. This clearing of program values is accomplished by the CLR key.

The CLR key sets all values to 0 from the line on which the cursor is located to the end of the program. Thus, if the cursor is on line 05 of a seven line program and your response to the query

DO YOU WISH TO CLEAR ALL BALUES FROM THE PRESENT CYCLE TO THE END? NO=0 YES=1

is a 'yes', only the values up through line 04 will remain intact. Clearing out a whole program simply requires that the cursor be on line 01 before the 'yes' response.

ENTR: When entering program values, a one or two digit number must be followed by the ENTR key in order to tab the cursor to the next position. Entering a three digit number will automatically tab the cursor to the next position. If you are editing a program and only need to change one parameter, press ENTR one or more times to tab over to that parameter.

NEXT/LAST: These keys are used to scroll up and down through your program. If the cursor is on line 2 and you need to edit a parameter on line 1, press LAST to move the cursor up to line 1. Press ENTR to then tab over to the parameter you wish to edit.

With the cursor on line 1 in the HEAT position, enter a number greater than 200. A good starting value is Ramp + 100 units. The cursor will now be in the FIL position. Enter a filament number between 0 and 15 (e.g. 4) and press ENTR. The cursor will now be in the VEL position. Enter a number between 0 and 255 (e.g. 50). With the cursor in the DEL position, enter a number for delay. A good starting value would be 130. Now enter a number between 0 and 255 for PULL (e.g 200). The cursor will now be on line 2 in the HEAT position. Press LAST

to scroll the cursor back up to line 1. You can continue to edit your program or load the glass and execute a pull sequence. Adjusting the parameter values for a particular pipette will be discussed next.

PARAMETER ADJUSTMENTS

Micropipettes programs are sufficiently different from patch pipette programs that the following information on parameter adjustments has been divided into two sections. Even if your research only requires one type of pipette, we recommend that you read through both sections for full appreciation of the capabilities of the puller. Please note that the programs referred to in the following text are not necessarily meant to pull functional pipettes, but are intended as an exercise to help develop an understanding of the programming process.

MICROPIPETTE FABRICATION

Consider the following micropipette program for 1.0mm O.D. quartz tubing:

HEAT	FILAMENT	VELOCITY	DELAY	PULL
750	4	50	130	200

Heat (Laser Output Power)

The heat setting will affect the length and tip size of the pipette. Generally speaking, higher heat settings tend to give longer and finer tips. The recommended starting heat value is the ramp test value plus 100 units. Values lower than 200 should be avoided, although the Heat can be set to any value desired with no danger of damaging the instrument. Timing the pulling cycle can provide the user with very useful information for developing pulling programs. At a heat setting of ramp value plus 100, a 1mm O.D.x 0.7mm I.D. quartz capillary tube will typically pull in 4 to 6 seconds after the PULL key is pressed. If the pull takes longer than eight seconds, and you are trying to pull a fine micropipette, increase the heat in 10 unit increments until the pull takes place in less than eight seconds. If the pull occurs in less than three seconds, decrease the heat until the pull takes place in 4-8 seconds. For the best micropipette reproducibility with the finest tips, you should select a heat value that melts the glass in 4 to 5 seconds. If the pull takes 10 - 15 seconds, there will be inherently more variablity in laser operation and pipette reproducibility will be compromised. In all cases, if the glass hasn't melted in less than 15 seconds, increase the heat.

Filament

The filament selected will also affect the time it takes to pull an electrode. Any filament can be used to form a microelectrode, but wider filaments tend to work more effectively. If you find that a wide filament is not melting the glass, try dropping down to a narrower filament which results with more power applied per unit length of glass. If you use a multiple line program, you will probably discover that as the glass has drawn out, the direct application of heat to the glass becomes even more effective. However, if the beam is not well centered on the glass, as the glass draws out you may find that the program stalls because the glass lies outside

of the effective region of the Gaussian beam profile. You can try using a narrower filament with a slow scan rate which will have the effect of applying more power to the glass.

Pull Strength Adjustment

Low values of pull strength in the range of 40-75 will give larger tips, while settings between 150-250 give the smallest tips. The pull strength can be set to any value desired with no danger of damaging the instrument. Once the trip velocity is attained, the hard pull is turned on for 1 second after the programmed delay has elapsed.

Velocity Adjustment (Trip Point)

The velocity value determines the point at which the heat is turned off. Velocity reflects the speed at which the two carrier bars are moving during the weak pull. The lower the velocity value the slower the speed of the bars when the trip point occurs. At that time the heat is turned off, and after the programmed delay has occurred, the hard pull is turned on.

Although the functional range of velocity is from 1-255, the velocity value is typically set between 45 to 60 for quartz micropipettes. For borosilicate or aluminosilicate micropipettes, velocity values should be increased to 100 -150.

In a multiple cycle program, it is possible for the glass to separate before the trip velocity is attained. Thus, the glass is subjected to direct heating as it is separating. Such an occurance can lead to difficulties in forming tips as well as lack of reproducibility. If you are using a one line looping program, try decreasing the velocity a few units at a time. If your program is a multiline program, decrease the velocity in the next to last line of the program. Decreasing the velocity will increase the amount of glass left in the last cycle of program, thus allowing the glass to attain the trip velocity before separating.

Delay

The Delay controls the timing of the start of the hard pull relative to the end of heating by the laser. The longer the delay, the cooler the glass will be when the hard pull occurs. In most cases when using a glass other than quartz, DEL will be 200 or more for microelectrodes. For quartz pipettes, DEL will usually be between 100 and 140.

PATCH PIPETTE FABRICATION

Patch pipette programs generally differ from programs for micropipette in three ways: The trip velocity is lower; the pull strength is typically turned off; more than one heating cycle is used.

Consider the following sample patch program for 1.0 mm O.D. by 0.5 mm I.D. borosilicate glass:

HEAT	FILAMENT	VELOCITY	DELAY	PULL
400	5	40	200	0

A program sequentially executes each line of code and then loops back to the start and begins again until the glass separates. A single line program such as this may execute 2 to 4 times before the glass separates.

Heat

The actual heat value used should be sufficiently high to allow the glass to melt in the first cycle in 5 to 15 seconds. Using a higher heat that melts the glass in less than 5 seconds will cause no problem in the first heating cycle, but may heat the glass too quickly in subsequent heating cycles, causing tips to curve or one pipette to be much longer than the other. A given heat may be dramatically more effective in melting glass that has been drawn down to a smaller diameter. If this problem occurs even with heats that take 15 seconds for the first cycle, the program may be rewritten as a multiple line program with all the same values but with a lower heat in the last line.

Filament

As the heat is restricted to shorter and shorter lengths of glass, the taper tends to become more rapid. The smallest scans (FILAMENTS 0,1,6,and 11) are rather extreme in this regard and seem more sensitive to the optical alignment of the puller. Remember that restricting the scan size will also cause a given heat setting to melt the glass more quickly.

The effect of filament size on pipette shape becomes less evident after the glass diameter has been reduced by one or more heating cycles. As the glass necks down, the smaller diameter section of the glass will melt much more rapidly than the rest of the glass, automatically restricting the length of glass that will melt and be drawn out. Increasing the filament size after the first few cycles will thus act primarily to decrease the effective rate of heating.

Velocity

Velocity determines the point at which the heat is turned off. If the value is too high, (greater than about 60) the glass will separate after the first heat cycle. As the velocity is decreased, the amount the glass is drawn-out by a given line will also decrease, and more cycles will be required to form a tip. When possible it is best to use values greater than 20 to avoid variability. The very narrow filaments may require lower velocities than the wider filaments.

Delay

Since the delay controls the timing of the start of the hard pull, the exact value is of little importance in a program that has no pull strength. The delay will contribute to the overall time between heating cycles, so that a very high value may have some cooling effect.

Pull

There is a constant gravitational pull on the carrier bars that can be felt when loading the glass. This pull is adequate to form fairly small tips (0.5 micron). If smaller tips are required, a moderate pull (25-50) may be used in the last line of the program. If a pull is used, the delay will have more effect. If a delay greater than 50 is used, the glass may break rather than draw down to a fine tip.

In order to obtain useable tips when pulling patch pipettes from quartz, some pull strength (30 to 60) must be used in the last line of the program. The greater the pull, the smaller the resulting tip. Pull may also be used in earlier lines, or in a single line program.

Note on the optical system alignment relative to patch pipettes:

The adjustment of the mirrors can have a strong effect on the formation of patch pipettes. As the glass draws down in diameter, the concentration of heat on the glass can increase or decrease depending on the positioning of the mirrors. If the incident beam and the reflected, focused beam are well positioned, the glass will stay in the center of the beam as it draws down and the heat will become more concentrated. If the beams are perfectly centered on the glass, it is possible that the as the glass draws down it will actually move out of the beam path. This be-

comes more critical when the glass has been drawn down to a small diameter by earlier heating cycles. In general, it is wise to avoid drawing the glass down to a very small diameter before the last line.

USE OF LARGER DIAMETER GLASS

The optical alignment of the P-2000 is based on a 1mm diameter standard (unless otherwise noted). If you want to use a larger diameter glass which can be loaded without rubbing on the holes in the shroud, it may still be possible to pull it without adjustment of the puller. The means of clamping the glass causes the center of larger diameter glasses to be displaced up and towards the user. This can place too much heat on the bottom of the glass, and can melt the glass away from the center of the laser beam resulting with a non-concentric pipette. An initial heating cycle should be used to draw the glass down to near 1 mm diameter. This will produce an hour-glass shape that is not well centered on the diameter of the original glass, but which may be worked in about the same way as 1 mm glass.

M A I N T E N A N C E

The P-2000 is a CO2 laser based micropipette puller. A number of safety shields, enclosures and interlocks have been built in to the instrument to protect the user from any radiation exposure. To assure continuous safe operation of the instrument:

- 1) Periodically check the top cover to verify that the cover is securely fastened to the baseplate;
- 2) Check to make sure the plastic top has not been distorted so as to allow access to laser radiation when the top is down.

Proper operation of the interlock switches is automatically verified with each successful pull sequence. Under no circumstances should the top cover (see Fig. 1) be removed or the interlock switches defeated. Up to 20 watts of CO2 laser power could be accessible under the top cover. Performance of procedures other than those specified herein may result in hazardous radiation exposure.

Pulley Adjustment

The position of the two pulleys which carry the cables from the solenoid to the puller bars is adjustable. This adjustment should be made only if the two pipettes formed from one pull are of quite different lengths. This inequality may be caused by scanning mirror operating errors, inappropriate parameter values (too high a heat for a given velocity), but may also be caused by unequal cable tensions. The cable adjustment is made by moving one or both of the pulleys to equalize the tension on the two cables. It should be explained at this point that there are two sets of stops in the system. There are the stops (allen head screws) in the puller bars slots against which the bars rest, and a stop to prevent the solenoid from being pulled out of its housing. The adjustment of the pulleys must be made so that the puller bars will still come up against their stops while the solenoid is not against its stop. The two cables should not be under tension when the bars are against their stops, this is the position they would be in just before pulling a pipette.

You should be able to press on either cable between the puller bar and the pulley (Fig.3t) and there should be about a 2mm deflection before the solenoid hits its stop. If the deflection is more or less, the pulley position should be changed. This is done by loosening the two screws above the pulley (Fig.3x) and turning the chrome eccentric cam (Fig.3v) to move the pulley in small increments until the two cables are of equal tension. If the puller bar no longer stops

against its stop in the slot, but stops against the cable, then the cam must be adjusted back until the carrier once more hits its stop. It is important that the carriers come up against their stops with no tension on the cables. If there is tension, the initial pull will depend on how tightly you hold the finger stops when the glass is clamped in the puller bars. If this happens, the pipettes will not be consistent from pull to pull.

Optical Alignment

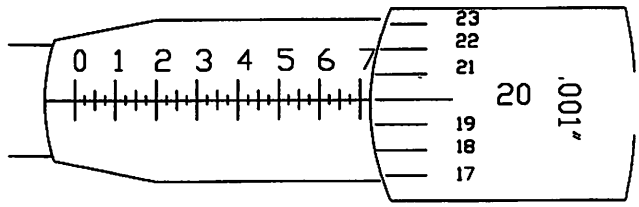
Proper alignment of both the front scanning mirror and rear collector mirror is critical for optimizing the performance of the laser puller. Both mirrors were adjusted for optimum performance before shipping the P-2000 from the factory. We recommend that you refrain from adjusting the mirrors until you have spoken with a member of the Sutter Instrument technical staff. In the event that you do need to adjust the mirrors, the following procedures can be used.

Scanning Mirror Tilt Adjustment

The scanning mirror is mounted on a tilting table. The tilt controls the elevation of the laser beam relative to the glass. The degree of tilt is controlled by a micrometer on the back of the puller. This micrometer pushes against an arm attached to the tilt table, which is spring-loaded against the micrometer. Turning the micrometer clockwise elevates the laser beam relative to the glass.

In order to protect the tilting mechanism, a shipping screw has been installed next to the micrometer. This screw is turned down prior to shipping to unload the micrometer and lock the table in place. Before using the puller, run this screw up (turn counter-clockwise) until it is nearly out of the baseplate. There should be a factory default setting indicated near the micrometer. Make sure that the micrometer is set as indicated. If you are not sure how to read a micrometer, consult the text below.

The micrometer is marked in 25 increments of 0.001" around its thimble and in 0.025" along its sleeve. The sleeve markings are numbered for each 0.1" and there is another mark to indicate 0.05". When the thimble is turned so that its zero mark is in line with the vertical line on the sleeve, the reading is an even increment of 0.025". Locate the highest 0.1" number visible and then add 0, 0.025, 0.05, or 0.075 to that number depending on the number of 0.025 in-



crements visible between the 0.1" line and the edge of the thimble. In this case the micrometer sleeve reveals 2 marks beyond 6 tenths of an inch, or .65" total.

If the thimble is rotated counter-clockwise from the 0 position, the number on the thimble next to the vertical line will increase, but no more 0.025" marks on the sleeve will appear until a full turn back to 0 has been made. The value from the thimble is added to the value on the sleeve to obtain the reading in .001". In this case the value is .018", which when added to .65" gives the final reading of .668".

The default setting supplied by Sutter Instrument should be adequate for most users. If you feel that this setting is not ideal, the micrometer allows for an easy change of tilt and a return to the old value. Since the micrometer is located about the same distance from the mirror as the target glass, a change in micrometer setting will produce about the same change in the elevation of the laser beam at the glass.

As there is no sensor-based beam positioning system built into the P-2000, you will need to make beam position adjustments utilizing qualitative information obtained with thermally sensitive paper. Scanning mirror adjustments are made as follows:

- 1) Remove the shroud which encloses the retro mirror. There are two screws holding the shroud to the cover plate.

- 2) Load a piece of quartz tubing into the puller.

- 3) Enter the following values into a program

HEAT- 200 FIL-5 VEL-0 DEL-100
P7ULL-0

- 4) Cut a 1.5cm x 3cm rectangle from a piece of FAX paper and slip it between the tubing and the retro mirror with the shiny side of the paper facing the tubing.

- 5) Lower the plastic top and press PULL. The laser will burn the fax paper in the region just above and below the glass. Note the symmetry (or lack of symmetry) of the burn pattern. Ideally, you want the burn pattern above and below the glass to be perfectly symmetric. Refer to Figure 4.

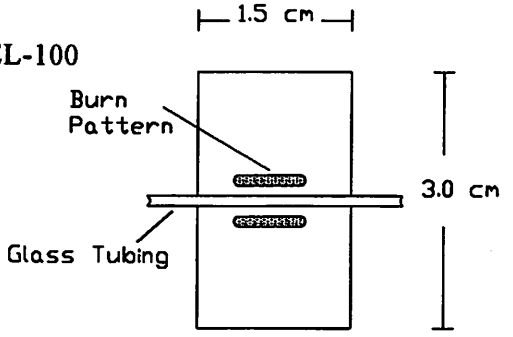


Figure 5: Laser Burn Pattern on Fax Paper

- 6) If the burn pattern is asymmetric, turn the tilt adjustment micrometer about 1/4 turn, then iteratively repeat the instructions from #4 on.

› 7) When the burn pattern is symmetric, you should note the micrometer setting, reinstall the shroud and proceed with the retro-mirror adjustment. Note: If any smoke was generated during the burn procedure, check to make sure that the retro mirror was not coated with particulate. If the mirror is dirty, refer to the cleaning instructions at the end of this section.

Retroreflective Mirror Adjustment

The mirror is mounted on a two stage manipulator allowing you to adjust the up/down and in/out positions. When the scales on the left side of the manipulator are aligned at 0, the mirror will be in its factory calibrated position.

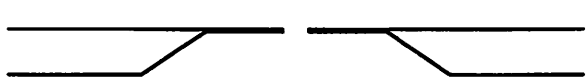
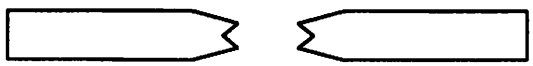
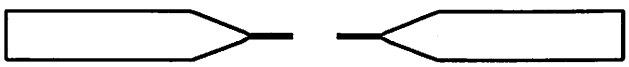
This manipulator should only be adjusted if the scales are not aligned or if the pipettes (or fibers) are noticeably asymmetric. To avoid accidental repositioning of the collector mirror, the manipulator has been fitted with 3/16 nuts which require a nut driver or wrench to rotate. Turning the top nut will change the up/down position of the mirror, while turning the nut facing you will change the in/out position of the mirror.

The manipulator travel limits are much greater than the travel limits of the mirror relative to the enclosure. Avoid exceeding the travel limits of the mirror as this may cause some damage to the manipulator.

The shape of the pulled pipettes is the best feedback for making adjustments to the retro mirror position. To determine the laser beam position relative to a pulled pipette, it is useful to mark the pipette with an orientation mark before removing it from the glass clamp. The chart on the following page lists some common pipette asymmetries and the corresponding mirror adjustments.

Cleaning The Retroreflective Mirror

The retro mirror surface is close to the target glass and may become coated by materials liberated by the heating of the glass. This is very likely to happen if the glass is dirty, covered with oil from the fingers, or partially coated. The mirror is mounted in a shroud that prevents operator access to the laser beam. The enclosure should to be removed for maintainance only.

Pipette Geometry	Problem/Adjustment
 Pipette as viewed from FRONT of instrument.	This condition results from too much heat being focused too low. MOVE THE MIRROR UP.
 Pipette as viewed from FRONT of instrument.	This condition results from too much heat being focused too high. MOVE MIRROR DOWN.
A. B. Pipettes as viewed from TOP of instrument.	Either geometry indicates that the retro mirror is focused too close to the glass. CHANGE THE IN/OUT POSITION OF THE MIRROR. TRY MOVING THE MIRROR IN TOWARDS THE GLASS UNTIL YOU ACHIEVE A 'BIRD BEAK' GEOMETRY AS IN THE NEXT FIGURE.
 Pipette as viewed from FRONT of instrument. Same pipette viewed from TOP of instrument.	This geometry indicates that the retro mirror is focusing the beam into the glass. The 'Bird Beak' geometry is an indication that you are very close to optimum. MOVE THE MIRROR IN TOWARDS THE GLASS TO MOVE THE BEAM FOCUS BEHIND THE GLASS.
 Pipette as viewed from any side.	A nively concentric pipette. The mirror is positioned correctly. HIDE THE NUT WRENCH!

Pipette Geometry/Mirror Adjustment Chart

The shroud is fastened to a coverplate that is, in turn, fastened to the baseplate. Simply remove the 2 slot head screws holding the shroud to the cover plate and the shroud should lift out. Make sure that you do not disturb the mirror or its adjustable mount. The mirror is chrome plated, and may be cleaned with a soft, clean cloth wetted with a solvent that produces no residue. You may be able to see a darkened area of contamination, which should come off quickly. Replace the shroud and insert the screws. Before you tighten the screws check the position of the thru-holes on the shroud to insure that the glass can be loaded without hitting the shroud. Tighten the screws firmly before putting the unit back in service.

L I M I T E D W A R R A N T Y

Sutter Instrument Company, a division of Sutter Instrument Corporation, limits the warranty on this instrument to repair or replacement of defective components for one year after the date of shipment, provided the instrument has been operated in accordance with the instructions outlined in the instruction manual.

Abuse, misuse or unauthorized repairs will void this warranty.

Limited warranty work will be performed only at the factory. The cost of shipment both ways to be borne by the owner.

This instrument is designed to pull glass pipettes for use on animal tissues. It is not intended to be used and should not be used in human experimentation or applied to humans in any way.

The limited warranty is as stated above and no implied or inferred liability for direct of consequential damages is intended.

D I S C L A I M E R

The pipette puller Model# P-2000 is designed for the specific use of creating micropipettes and no other use is recommended.

This instrument should only be used in a laboratory environment for use on animal tissues. It is not intended to be used and should not be used in human experimentation or applied to humans in any way. This is not a medical device.

Do not open or attempt to repair the instrument without expressed and explicit instructions from Sutter Instrument Company. Extreme heat and high voltages present within the instrument could cause injury.

Do not allow unauthorized and or untrained operators to use this device.

Any misuse will be the sole responsibility of the user/owner and Sutter Instruments assumes no implied or inferred liability for direct or consequential damages from this instrument if it is operated or used in any way other than for which it is designed.

SUTTER INSTRUMENT COMPANY

40 LEVERONI CT., NOVATO, CA 94949

PHONE: 415-883-0128 FAX: 415-883-0572 TELEX: 6503036228 MCI UW

SUTTER INSTRUMENT GLASS CAPILLARIES

FORMULATIONS: Sutter currently offers three formulations of glass; borosilicate, aluminosilicate and quartz. Borosilicate glass has been the material of choice for most routine work. It is used for microelectrodes, patch-type pipettes, microperfusion and collection pipettes, and microinjection needles. Aluminosilicate glass, because of its special properties, is usually reserved for the production of ultrafine tip recording microelectrodes, ion-selective micropipettes and certain patch type pipettes. Quartz possesses superior physical characteristics for physiological research when compared with other glasses, but has rarely been used because its melting point exceeds that of conventional heating elements. With the introduction of Sutter's laser-based P-2000 pipette puller, investigators can now utilize quartz in pipette fabrication.

The characteristic and behavioral differences between borosilicate and aluminosilicate can be summarized as follows: 1) Aluminosilicate melts at higher temperatures and is workable over a much narrower temperature range than borosilicate. 2) With the exception of the final tapers on very fine tipped micropipettes, the original ratio of the capillary's inner to outer diameter will remain unchanged over the total taper length for pipettes formed from borosilicate glass. However, aluminosilicate glass shows a marked tendency to thin out as it is drawn to a tip. This behavior has allowed us to form extremely fine tips (200-300 Angstroms) with short tapers (5-6mm).* 3) The resistivity of aluminosilicate is several orders of magnitude greater than borosilicate; thus, it will reduce leakage currents when used for ion-selective pipettes. 4) Aluminosilicate is somewhat 'harder' than borosilicate, thus it is less tolerant of shearing forces, but is stronger overall.

Quartz (or synthetically produced fused silica) is distinctly different from the other glasses and exhibits the following characteristics: 1) Superior mechanical strength, and ultrafine tip formation not achievable with other glasses. We have pulled electrodes from thin wall quartz with tip diameters less than 300 Angstroms. Pipettes made from quartz are stronger than pipettes made from other glasses. 2) Superior electrical characteristics demonstrated by a low dielectric constant, low loss factor and a volume resistivity that is orders of magnitude greater than borosilicate and aluminosilicate. Pipettes made from quartz should have inherently less noise generating properties than pipettes made from any other glass. 3) All common glasses except quartz incorporate metal ions to decrease their melting point. Recording artifact and alteration of channel kinetics due to these metal ions may therefore be minimized with quartz.

Investigators are again reminded that quartz and fused silica cannot be used with metal filament based pipette pullers. Please refer to the P-2000 data sheet for additional information.

SIZES: Sutter offers borosilicate capillaries in a wide variety of sizes as well as several multibarrel configurations. Two wall thickness classes are recognized: standard wall—the ratio of inner to outer diameter is less than .75; and thin-wall—where the ratio is greater than .75. All other factors being equal, the thicker the wall of pulled tubing, the longer will be the taper and the finer the final tip. Thus, thin-walled capillaries are recommended for microinjection needles and low resistance (less than 50 Mohm) voltage clamp pipettes. Standard wall tubing is suitable for microelectrodes, patch-type pipettes, and those pipettes where additional wall thickness is necessary for mechanical reasons. The aluminosilicate capillaries are the thickest wall currently available and are a Sutter Instrument exclusive. Thin or thick wall quartz capillaries are available with an outer diameter of 1.0mm only.

FILAMENTS: For situations where pipette filling is difficult, most capillary sizes are available with a glass filament.

INFORMATION: Please contact us at the address or phone number above if you have any questions about available glass or its recommended uses. Information on cleaning and storing glass capillaries is also available.

*Our observations on glass behavior have been made using instruments manufactured by Sutter Instrument Company (pullers), and documented using our scanning electron microscope facilities. Sutter Instrument Company cannot guarantee that like results can be obtained with other equipment.

OVERSEAS REPRESENTATIVES

BIO-LOGIC

1, Rue de L'Europe
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Phone: 33 76 98-68-31

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AUSTRALIA
Fax: 61 2 9 58-26-55
Phone: 61 2 9 58-26-88

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Cheng Teh Road
Taipei, Taiwan ROC
Fax: 886 2 882-6645
Phone: 886 2 882-5343

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RG8 7HU ENGLAND
Fax: 44 73 4 84-53-74
Phone: 44 73 4 84-38-88

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Akashibucho, Okazaki
444-02 JAPAN
Fax: 81 564 54-32-07
Phone: 81 564 54-12-31

SCIENCE PRODUCTS AG

Zegliweg 14
CH-8606 Nanikoa/Uster
SWITZERLAND
Fax: 41 01-9400118
Phone: 41 01-9400111

SUTTER INSTRUMENT COMPANY

PULLER PRICE LIST

MODEL P-2000	Laser based quartz pipette puller. Programmable microprocessor controlled puller for fabricating micropipettes and patch type pipettes. Please see information sheet for details.	11,900.00
MODEL P-97	New and improved version of the original Flaming/Brown Micropipette Patch Pipette Puller. Featuring humidity controlled heating chamber, higher power, increased versatility and improved functionality. Please see information sheet for details.	6,450.00
MODEL P-87	Flaming/Brown Patch Pipette/Micropipette Puller. Microprocessor controlled programmable puller for fine tip, patch tip and microinjection needles. 110/220V, 50/60 Hz. Please see information sheet for details.	5,725.00
MODEL PC-84	Programmable Patch Pipette/Micropipette Puller, Programmable, microprocessor controlled puller for fabricating patch type pipettes, and microinjection needles with tip diameters greater than–0.2 micron. Please see information sheet for details.	4,950.00
MODEL P-30	Vertical Pipette Puller. Please specify nichrome or platinum/iridium filament when ordering. Please see information sheet for details.	2,995.00
UPGRADE TO P-97	P-87 upgrade to a P-97. All other Flaming/Brown Type pullers to a P-97.	1,500.00 3,950.00
UPGRADE TO P-87	P-77 upgrade to a P-87 P-80C upgrade to a P-87 P-80/PC upgrade to a P-87	3,150.00 3,150.00 3,150.00
OVERSEAS PRICING	Overseas pricing varies from country to country depending on shipping costs, customs charges, and various import taxes. Please consult your local representative or contact Sutter Instrument Company for a quotation.	

Order From: Sutter Instrument Company
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Fax: (415) 883-0572

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SUTTER INSTRUMENT COMPANY

LAMBDA-10 OPTICAL FILTER WHEEL PRICE LIST

LAMBDA-10 **$ 4,900.00**

The Lambda-10 comes complete with a filter wheel, its accompanying support unit consisting of a base and mounting rods, a rack mountable controller unit with a controller/filter wheel interface cable and a parallel interface cable. Also included are two drop in filter holders, and ten blanking discs.

ACCESSORIES

CATALOG #	PRICE
High-Speed Shutter Assembly	$ 995.00
Nikon Microscope Adaptor	$ 300.00
Olympus Microscope Adaptor	$ 300.00
Zeiss Microscope Adaptor	$ 200.00
Additional Slide-in Filter Holders	$ 50.00
Additional Drop-in Filter Holders	$ 30.00

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HUXLEY/WALL TYPE MICROMANIPULATOR

PRICE LIST

MP-85	Complete. Huxley manipulator, coarse movement MM/33, rotating base.	$3150.00
WEDGES	Fifteen degree increments.	60.00/ea
SPACERS	One inch increments.	60.00/ea
MAGNETIC FEET	Set of three.	25.00
RBI	Rotating base only.	425.00
COARSE MANIPULATOR	MM/33	695.00
RM1	Rotating mount for coarse manipulator.	120.00

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SUTTER INSTRUMENT COMPANY

K.T. BROWN TYPE MICROPIPETTE BEVELER

PRICE LIST

MODEL NO.	ITEM	CATALOG NO.	PRICE
BV-10	Micropipette Beveler System Includes: #100, #002, #001, #101, #102, #003, #003A, #008, #007, #009, #106 and 2 abrasive plates of your choice.	BV-10	$2295.00
	Electrode Impedence Meter (BV-10M)	100	695.00
	Micromanipulator	002	595.00
	Base Unit, including Motor and Pedestal	001	1195.00
	Modification for 220V		120.00
	6-inch Reference Lead	101	7.00
	2-inch Active Lead, Platinum	102	7.00
	Reference Wick	003	0.90
	Reference Wick Holder	003A	15.00
	0.05u Abrasive Plate (.1u to .3u tip sizes)	005	150.00
	0.3u Abrasive Plate (3/10u to 1u tip sizes)	006	150.00
	Diamond Abrasive Plate, Coarse (5u to 50u tip sizes)	104C	150.00
	Diamond Abrasive Plate, Fine (2u to 20u tip sizes)	104D	150.00
	Diamond Abrasive Plate, Extra Fine (1/2u to 5u tip sizes)	104F	150.00
	Bottle, Pedestal Oil (30W Oil)	008	2.75
	Bottle, Degreaser	007	3.50
	Instruction Manual	009	15.00
	Replacement Drive Belt	106	12.50

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Effective 5/1/91

effective 01/01/93

Borosilicate Tubing

Catalog #	O.D.	I.D.	Length	Qty/Pkg	Price
Standard Wall Borosilicate Tubing with Filament					
BF100-50-10	1.00 mm	0.50mm	10 cm	225	$25.00
BF100-50-15	1.00 mm	0.50mm	15 cm	225	$38.00
BF100-58-10	1.00 mm	0.58mm	10 cm	250	$21.00
BF100-58-15	1.00 mm	0.58mm	15 cm	250	$30.00
BF120-60-10	1.20 mm	0.60mm	10 cm	225	$28.00
BF120-69-10	1.20 mm	0.69mm	10 cm	250	$26.00
BF120-69-15	1.00 mm	0.69mm	15 cm	250	$57.00
BF150-75-10	1.50 mm	0.75mm	10 cm	225	$60.00
BF150-86-10	1.50 mm	0.86mm	10 cm	250	$56.00
BF150-86-15	1.50 mm	0.86mm	15 cm	250	$85.00
BF200-100-10	2.00mm	1.00mm	10 cm	225	$87.00
BF200-116-10	2.00 mm	1.16mm	10 cm	250	$72.00
BF200-116-15	2.00 mm	1.16mm	15 cm	250	$107.00
Standard Wall Borosilicate Tubing without Filament					
B100-50-10	1.00 mm	0.50mm	10 cm	225	$25.00
B100-50-15	1.00 mm	0.50mm	15 cm	225	$38.00
B100-58-10	1.00 mm	0.58mm	10 cm	250	$12.00
B100-58-15	1.00 mm	0.58mm	15 cm	250	$18.00
B120-69-10	1.20 mm	0.69mm	10 cm	250	$17.00
B120-69-15	1.20 mm	0.69mm	15 cm	250	$26.00
B150-86-10	1.50 mm	0.86mm	10 cm	250	$25.00
B150-86-15	1.50 mm	0.86mm	15 cm	250	$37.00
B200-116-10	2.00 mm	1.16mm	10 cm	250	$41.00
B200-116-15	2.00 mm	1.16mm	15 cm	250	$64.00
Thin-Wall Borosilicate Tubing with Filament					
BF100-78-10	1.00 mm	0.78mm	10 cm	250	$25.00
BF100-78-15	1.00 mm	0.78mm	15 cm	250	$37.00
BF120-94-10	1.20 mm	0.94mm	10 cm	250	$34.00
BF120-94-15	1.20 mm	0.94mm	15 cm	250	$53.00
BF150-110-10	1.50 mm	1.10mm	10 cm	225	$60.00
BF150-117-10	1.50 mm	1.17mm	10 cm	250	$68.00
BF150-117-15	1.50 mm	1.17mm	15 cm	100	$42.00
BF200-156-10	2.00 mm	1.56mm	10 cm	250	$90.00
BF200-156-15	2.00 mm	1.56mm	15 cm	100	$55.00
Thin-Wall Borosilicate Tubing without Filament					
B100-75-10	1.00 mm	0.75mm	10 cm	225	$25.00
B100-75-15	1.00 mm	0.75mm	15 cm	225	$38.00
B120-90-10	1.00 mm	0.90mm	10 cm	250	$28.00
B150-110-10	1.00 mm	1.10mm	10 cm	250	$44.00

Aluminosilicate Tubing

Catalog #	O.D.	I.D.	Length	Qty/Pkg	Price
Standard Wall Aluminosilicate Tubing with Filament					
AF100-53-10	1.00 mm	0.53mm	10 cm	100	$15.00
AF100-53-15	1.00 mm	0.53mm	15 cm	100	$22.00
Thin-wall Aluminosilicate Tubing with Filament					
AF100-68-10	1.00 mm	0.68mm	10 cm	100	$46.00
AF120-85-10	1.20 mm	0.85mm	10 cm	100	$50.00
AF150-100-10	1.50 mm	1.00mm	10 cm	100	$68.00
Thin-Wall Aluminosilicate Tubing without Filament					
A100-68-10	1.00 mm	0.68mm	10 cm	100	$23.00
A120-85-10	1.20 mm	0.85mm	10 cm	100	$25.00
A150-100-10	1.50 mm	1.00mm	10 cm	100	$68.00

Quartz Tubing

Quartz Tubing without Filament					
Q100-50-7.5	1.00 mm	0.50mm	7.5 cm	100	$90.00
Q100-50-10	1.00 mm	0.50mm	10 cm	100	$121.00
Q100-70-7.5	1.00 mm	0.70mm	7.5 cm	100	$71.00
Q100-70-10	1.00 mm	0.70mm	10 cm	100	$94.00
Q120-90-7.5	1.20 mm	0.90mm	7.5 cm	100	$46.00
Q120-90-10	1.20 mm	0.90mm	10 cm	100	$62.00
Q150-75-10	1.50 mm	0.75mm	10 cm	100	$64.00
Q150-110-10	1.50 mm	1.10mm	10 cm	100	$64.00
Q150-115-10	1.65 mm	1.15mm	10 cm	100	$63.00
Quartz Tubing with Filament					
QF100-50-7.5	1.00 mm	0.50mm	7.5 cm	100	$102.00
QF100-50-10	1.00 mm	0.50mm	10 cm	100	$135.00
QF100-70-7.5	1.00 mm	0.70mm	7.5 cm	100	$81.00
QF100-70-10	1.00 mm	0.70mm	10 cm	100	$107.00

Specialty Glass Tubing

Catalog #	Barrel #	O.D / I.D.	Length	Qty/Pkg	Price
Thin Septum Borosilicate tubing					
BT-150-10	Theta	1.50mm	10cm	100	$58.00
Multi-Barrel Borosilicate Tubing with Filament					
2BF1-50-10	2 barrel	1.00/0.50mm	10 cm	75	$36.00
2BF1-75-10	2 barrel	1.00/0.75mm	10 cm	75	$36.00
2BF5-86-10	2 barrel	1.50/0.86 mm	10 cm	100	$49.00
2BF5-86-15	2 barrel	1.50/0.86 mm	15 cm	100	$73.00
3BF1-50-10	3 barrel	1.00/0.50 mm	10 cm	75	$43.00
3BF1-75-10	3 barrel	1.00/0.75 mm	10 cm	75	$43.00
3BF2-69-10	3 barrel	1.00/0.60 mm	10 cm	100	$75.00
3BF2-69-15	3 barrel	1.00/0.60 mm	15 cm	100	$109.00

Sutter Instrument Company

40 Leveroni Court Novato, CA 94949 Phone: 415-883-0128 FAX: 415-883-0572

Sutter Instrument Company reserves the right to modify prices or specifications at any time.

SUTTER INSTRUMENT COMPANY
PIPETTE PULLER ACCESSORY PRICE LIST

FOR MODELS:
P-87, P-80/PC, P-80C,
PC-84, P-77B

Appropriate filament selection depends on your research application, but a general guideline for filament selection is as follows. Box filaments are recommended for large diameter, double-barrel or aluminosilicate glass. Box filaments are particularly suitable for slice preparations where long, parallel walls would aid penetration. If using a box filament, the size of the square box should be approximately 1.00mm to 1.50mm larger than the outside diameter of the glass you are using. Trough filaments are an excellent general purpose filament, and are recommended for patch pipettes produced from standard or thin wall glass. For either type of filament, increasing filament width tends to increase the length of the pipette taper. If you are in need of further assistance, please feel free to contact our technical support staff.

BOX FILAMENTS

Catalog #	Description	Price
FB215B	2.0mm Square Box Filament, 1.5mm Wide	9.75
FB220B	2.0mm Square Box Filament, 2.0mm Wide	9.75
FB230B	2.0mm Square Box Filament, 3.0mm Wide	9.75
FB255B	2.5mm Square Box Filament, 2.5mm Wide	9.75
FB315B	3.0mm Square Box Filament, 1.5mm Wide	9.75
FB320B	3.0mm Square Box Filament, 2.0mm Wide	9.75
FB330B	3.0mm Square Box Filament, 3.0mm Wide	9.75

TROUGH FILAMENTS

Catalog #	Description	Price
FT315B	1.5mm Wide Trough Filament	9.75
FT320B	2.0mm Wide Trough Filament	9.75
FT330B	3.0mm Wide Trough Filament	9.75
FT345B	4.5mm Wide Trough Filament	9.75

Please see reverse side for additional listings.

FOR MODEL
P-30

P-30 FILAMENTS

Catalog #	Description	Price
P30T15	1.5mm Wide Trough Filament	9.75
P30T20	2.0mm Wide Trough Filament	9.75
P30T30	3.0mm Wide Trough Filament	9.75
P30N	Nichrome Filament	5.00

FOR MODEL
P-77A

LOOP FILAMENTS FOR SERIAL NO. 160 AND ABOVE

Catalog #	Description	Price
FL315A	3.0mm Loop Filament, 1.5mm Wide	9.75
FL320A	3.0mm Loop Filament, 2.0mm Wide	9.75
FL325A	3.0mm Loop Filament, 2.5mm Wide	9.75

LOOP FILAMENTS FOR SERIAL NO. BELOW 160

Catalog #	Description	Price
FL315X	3.0mm Loop Filament, 1.5mm Wide	9.75
FL320X	3.0 mm Loop Filament, 2.0mm Wide	9.75
FL325X	3.0mm Loop Filament, 2.5mm Wide	9.75

ACCESSORIES

Catalog #	Description	Price
FS1875	Platinum/Iridium Sheet 18mm X 75mm, 0.002" thick	90.00
FFOOXA	Loop Forming Tool	5.00
NTOXAB	Nitrogen Tank (full)	130.00
IMOXAB	Instruction Manual	15.00
BKOOXA	Kit to Convert P77,P77A to Model B trough/box filament system	300.00

ORDER FROM:

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SUTTER INSTRUMENT COMPANY

Sutter Instrument Company is an international leader in the manufacture of precision instrumentation for the biological sciences. With a wide range of employee expertise, Sutter Instrument Company combines cutting edge technology with attention to quality in bringing innovative and effective products to the market.

Founded in 1974, Sutter Instrument Company has grown from a modest "garage" operation to an integrated engineering and manufacturing facility occupying 16,000 sq. ft. Our shop facilities employ state-of-the-art CNC machining and turning centers for volume production of our precision mechanical components.

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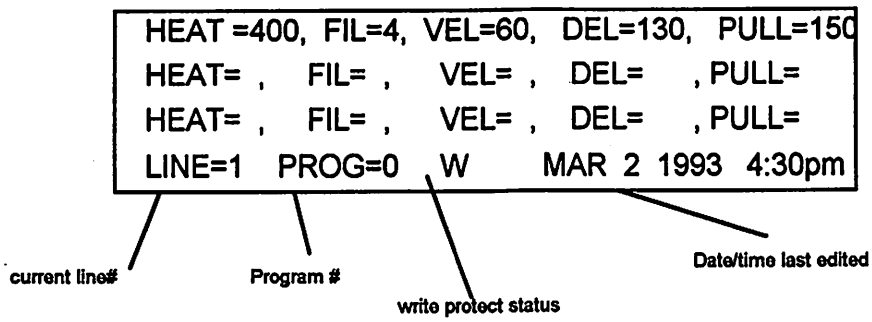
ADDENDUM TO P-2000 MANUAL

The P-2000 has several new features that were developed after the manual was last printed.
These new features are:
1) A write protect control function, to allow your program to be write protected.
2) A clock that is used to establish the date/time of a program edit, and the length of time the heat is on during program execution.
3) A memory test to test the integrity of the RAM.

The program display has changed such that it now conveys the write protection status of your program and the date/time the program was last edited. A typical display appears as follows:


HEAT =400, FIL=4, VEL=60, DEL=130, PULL=150
HEAT= , FIL= , VEL= , DEL= , PULL=
HEAT= , FIL= , VEL= , DEL= , PULL=
LINE=1 PROG=0 W MAR 2 1993 4:30pm
current line#
Program #
write protect status
Date/time last edited

Control of these new features is accessed through the CLR key. Pressing CLR gives you the following message:

DO YOU WISH TO CLEAR ALL VALUES FROM THE
PRESENT CYCLE TO THE END? NO=0 YES=1

Entering No=0 will provide you with access to the following P-2000 Control Functions:

Function #	Function Name	Description
1	RAMP TEST	Run the Ramp Test
2	WRITE-PROTECT THE PROGRAM	Lock or unlock the write-protection
3	RESET TIME AND DATE	Set the clock
4	MEMORY TEST	Test the integrity of the RAM

Function #1: RAMP TEST

This fuction operates as described in the manual.

Function #2:WRITE-PROTECT THE PROGRAM

Activate (WriteProtect) or inactivate (Write) the write protection mode. Inactive mode (W) allows program to be edited. Active mode (WP) prevents program from being edited. The write-protect status is reported on the bottom line of the program display.

Function #3:RESET TIME AND DATE

This function allows you to set the system clock. The clock is used to establish the date and time of the last program edit as displayed on the bottome line of the program display.

Function #4:MEMORY TEST

Perform a non-destructive test of the RAM. Press RESET to reset the system after performing this test.

Timed Heat Display

With the addition of the clock, the time the heat is active during the program is displayed at the end of a pull sequence. This is not to be confused with the time the laser is active. The laser is activated prior to incidence with the glass to allow the output to stabilize. The time the heat is active corresponds to the time that the laser beam is actually directed towards the glass.

The time the heat is on can be useful for developing micropipette programs. It is also a useful parameter for helping to determine variability in the pulling sequence.